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WAVETEK

MP MASTER
MA30813

WAVETEK

OPERATING HANDBOOK

CLM-1000

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The customer MUST obtain a RETURN AUTHORIZATION NUMBER from the Customer Service Department prior to returning any equipment for warranty or non-warranty repair. Wavetek accepts no liability for any instrument or subassembly returned to the factory without this number. Any correspondence regarding returned instruments or subassemblies should be referenced to that number.

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STORAGE TEMPERATURE CAUTION

Calibration and log data are stored in nonvolatile memory using an internal lithium battery. This device has storage temperature limits from -20°C to +70°C. Storage of the CLM-1000 at temperatures exceeding these limits may cause the calibration or log data to be lost.

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OVERALL CAPABILITY

The CLM-1000 is a frequency agile measurement receiver with user features which simplify the leakage maintenance program for a CATV system. It was designed to make cable leakage measurements and provide output data which can be used to make Cumulative Leakage Index (CLI) calculations and maintain a cable leakage log.

Caution: To avoid damage to sensitive electronic hardware, an antenna is all that should be directly connected to the CLM-1000.

The CLM-1000 is designed to make a 3 meter referenced 20 μV/m measurement at distances up to 200 feet using proprietary signal processing techniques. The frequency range of this instrument is from 50 to 550 MHz. Tuning can be accomplished by either frequency or channel. There are 10 channel plans which the user may select from. In addition to this, the user may specify a custom plan to be programed at the factory.

The CLM-1000 has a built-in preselector to minimize the intermodulation problems from off-air signals. This preselector has three band ranges which are listed under the PRESELECTOR heading on the preceding pages of this manual. The preselector may be disabled and an external preselector used.

The CLM-1000 operator interface is a 32 key keypad and a 2 line by 40 character liquid crystal display (LCD). The keypad provides full alpha-numeric capability. The display provides all necessary information about the CLM-1000. An RS-232 interface is provided to download leakage information to a personal computer or a serial line printer. This interface may also be used for remote data acquisition in specialized applications.

The Field Strength readout is in μV/m, taking into account both antenna factor and distance from the leak. Antenna factors are provided internally for a tuned dipole and a quarter wave vertical whip. There is also a provision for customers who require custom factors for their own characterized antenna. The leak distance range can be from 10 to 200 feet. We recommend that all final measurements be taken at 10 feet or the current reference distance for best accuracy.

An audible alarm with a range from 5 to 999 μV/m is provided. This alarm has 3 modes. The first mode will activate the alarm anytime the set threshold is exceeded. The second mode reacts in the same manner as the first however, it will only be activated when a video signal is present. The third mode will disable the alarm. Each of the CLM-1000 operational parameters can be stored in one of ten stored settings. The stored settings allow any combination of instrument settings to be recalled easily. This simplifies monitoring activities, whether from patrol vehicles or detailed search efforts on foot.

A bar graph display on the 40 character LCD aids in locating a leak. It represents a real-time indication of the field strength of the received signal. The entire detection range of the instrument is indicated on the bar graph as well as in numeric form. A peak hold detection mode enables reliable peak field strength measurements to be made and logged. The peak measurements will not effect the bar graph display.

The CLM-1000 has logging capability for up to 100 leaks, the following leak information is logged:

Field strength, frequency, distance, and antenna type,
location, time, cause of leak

(The user need only enter the location and the cause-the rest of the data is stored automatically.)

The log information is formatted with a header containing the date of the log entries, system name, route name, serial number of the CLM-1000, start and stop odometer readings, and user name. The header information can be changed by simple entries from the front panel. The operator may enter up to 5 route changes on one complete log. This enables the operator to cross over into other routes if required. A route change will force a new header when the log information is printed.

The CLM-1000 can be powered by its internal battery or from the dashboard power connector in the service vehicle. This power connector is simply a cigarette lighter adaptor which is provided.

INSTRUMENT SPECIFICATIONS

Frequency Range
50 to 550 MHz in 6.25 kHz steps or channel tuning by standard and HRC plans, withor without offsets; set at the factory or configured by the user with front panel commands or through the RS-232 interface.

RF Pre-selection
72 to 76 MHz, 108 to 139 MHz, and 225 to 400 MHz. May be disabled by front-panel control.

Field Strength Measurement Range
10 mV/m to 2000 mV/m with a half-wave dipole (readable down to 1mV/m).

RF Input Sensitivity
<0.5 uV using proprietary signal recovery techniques.

RF Input Accuracy
±2.0 dB, (typ. ±1.5 dB) internal filter mode
±2.5 dB, (typ. ±2.0 dB) external filter mode

Flatness
±1.0 dB @ 100 mV input (25 deg. C)

Input Impedance
75 Ohms

Measurement Bandwidth
100 Hz effective using proprietary signal recovery.

Audio Output
AM detection unless on an audio carrier in the channel tuning mode, superimposed alarm signal, volume control by front-panel potentiomer.

Digital Interface
Dual-port, RS-232, front-panel DB-25 connector.

Battery Life
2 hours continuous, from full charge (internal NiCad battery pack)

Alternate Power Sources
External power source +13.5 to +16 VDC, 800 ma.

Operating Temperature
0°C to +40°C

Storage Temperature
-20°C to +70°C

UNIT OPERATION

Front Panel Controls

Front panel operating controls are described in Table 1 and displayed in Figure 1.

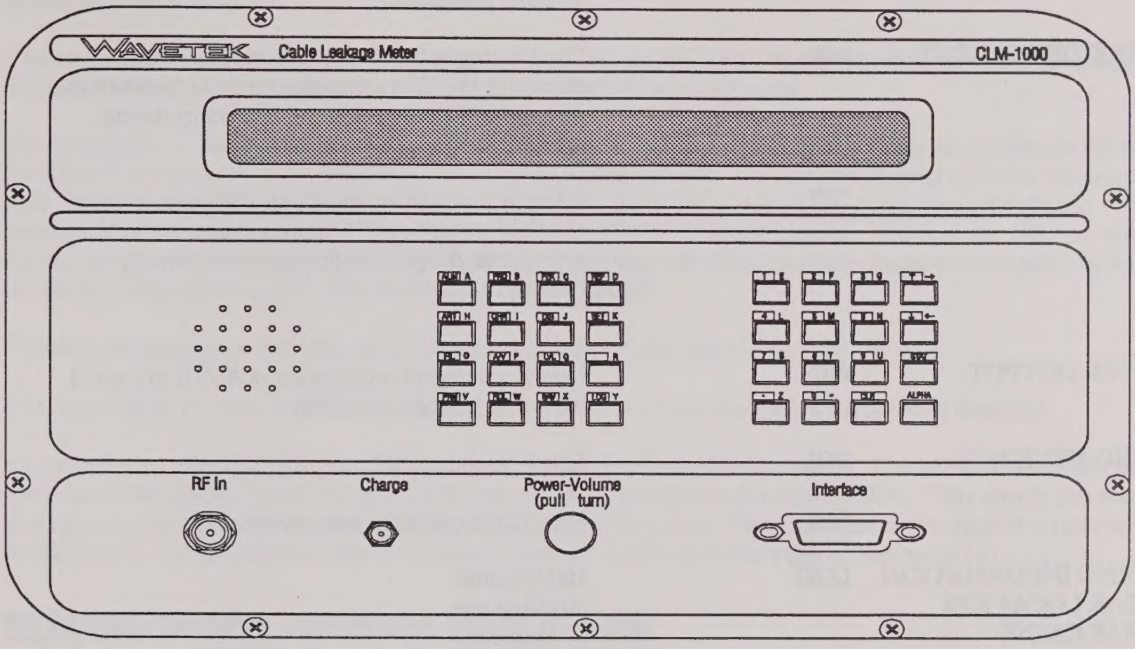


Figure 1. CLM-1000 Front Panel

Table 1: Front Panel Operating Controls (Keys)

Function	Key	Description
ALARM TRIP LEVEL	ALM	Selectable from 5 to 999 µV/m
FREQUENCY TUNING	FRQ	50 to 550 MHz
PEAK HOLD	PEK	Causes the digital readout to display only the peak level of the measurement. The bar graph continues to give real-time indication.
REFERENCE	REF	Allows the unit to be field calibrated to a 20 µV/m reference field
ANTENNA TYPE	ANT	Tuned dipoles, monopoles, one user defined
CHANNEL TUNING	CHN	As per channel plan programmed
DISTANCE	DIS	Leak distance entry from 10 to 200 feet

Function	Key	Description
INSTRUMENT SETUP	SET	Used to set the serial communication parameters
PRESELECTOR BYPASS	FIL	Causes the internal preselector to be bypassed, prompts for the insertion loss of the required external preselector.
AUDIO/VIDEO SELECT	A/V	Used to toggle between the audio and visual carriers in the channel tuning mode or between the AM and FM detectors in the frequency tuning mode.
LEVEL	LVL	A toggle function which allows a direct readout of the field strength or RF input voltage. All field strength readings are referenced to a 3 meter distance.
PRINTER OUTPUT	PRN	Download logged information in ASCII to a serial printer or personal computer
STORED SETTINGS	RCL	Recall 10 complete front-panel settings
	SAV	Save 10 complete front-panel settings
LOGGING INFORMATION LEAK LOCATION LEAK CAUSE	LOG	100 locations 20 characters 20 characters
ALPHANUMERIC & EDITING KEYS		A thru Z; 0 thru 9; period; up, down, left and right arrows, space ( ); clear(CLR)
ALPHA SELECT	ALPHA	Causes the keys to be interpreted as alpha charac ters
UNIT STATUS	STAT	Used to display the unit operating temperature and battery voltage
ENTER	STAT	Used as carriage return for accepting user-entered data

INITIAL TURN-ON AND DISPLAY FIELDS

When the CLM-1000 is turned on, the LCD will display the information in the format shown in Figure 2. The display is divided into fields that contain the operational information of the CLM-1000. The power-up CLM-1000 operating parameters will be the same as those when the unit was last operational.

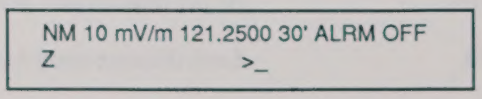


Figure 2

The field in the upper left-hand corner of the display indicates the CLM-1000 measurement mode. NM shows that the NorMalized mode of measurement is active. Field strength measurements are made in the NorMalized mode. A field strength measurement is a combination of input voltage, distance from the leak, and the antenna factor. Pressing the LVL key activates the ABsolute measurement mode. This mode indicates the input voltage at the RF In connector. The LCD will prompt an "AB" in the upper left-hand corner when in this mode.

The second field in the top line of the display is the measurement field. In the NorMalized mode the reading will be in uV/m units. In the ABsolute mode, the reading will be in µV units.

The third field, in the middle of the top line of the LCD, displays the frequency or channel number to which the CLM-1000 is tuned. The frequency is always displayed in MHz. No units are displayed in the frequency field. Pressing the CHN key will convert the CLM-1000 operation to the closest video frequency in the presently selected channel plan. The channel number and VID will be displayed. Pressing the A/V key will display the channel number and AUD. Pressing the FRQ key will return to the frequency mode and display the present video frequency to which the CLM-1000 is tuned.

The field to the right of the frequency display is the distance in feet or metres to the leak.

The last field on the first line of the LCD is the alarm status. Upon power up, the alarm is disabled.

The second line of this display is used for the analog bar graph and for data entry. The left half of the display contains the bar graph. There are 20 solid blocks which cover a dynamic range of 72dB. This area is also used to display the location and cause prompts during log entry or review. The right half of the display is reserved for data input. All numeric and alphanumeric entries are displayed to the right of the cursor (>).

SELECTING CHANNEL PLANS FOR THE CLM-1000

To change these parameters, use the alphanumeric keypad and complete the following entries as shown below. Only enter the characters that are shown between the quotation marks (" "), and STAT means depress the STAT key.

Standard NCTA	"STD"	STAT
Standard HRC	"HRC"	STAT
Offset NCTA	"OST"	STAT
Offset HRC	"OHR"	STAT
PAL A	"PAL"	STAT
PAL B & G	"PBG"	STAT
Belgium	"BEL"	STAT
Germany	"GER"	STAT
Israel	"ISR"	STAT
Hong Kong	"HKT"	STAT

The corresponding frequencies for each of these plans and the offset frequencies from video to audio carriers are listed in Tables 2-11 located at the end of this manual.

DATA ENTRY

During numeric data entry the numbers are entered first, then the appropriate function key is depressed. Numbers entered are displayed on the second line of the LCD to the right of the cursor(>). Pressing a function key transfers the number to the appropriate data field. The functions which use data entry are listed

in Table 2.

Table 2: Numeric Entry Functions

Function	Key
Frequency	FRQ
Channel	CHN
Distance	DIS
Alarm Level	ALM
Antenna	ANT
Stored setting save	SAV
Stored setting recall	RCL
External Filter insertion loss	FIL

The logging functions require both numeric and alpha keys. To activate the alpha characters press the ALPHA key. An asterisk will appear in the lower right hand corner of the LCD (refer to Figure 3). Alpha entries are displayed to the right of the cursor (>). If numeric entries are required during an alpha sequence, press the ALPHA key again and complete the required numeric entries.

Figure 3

STEP FUNCTIONS

The numerical value of the following functions can be incremented or decremented using the up/down arrow keys. Frequency steps occur in 6.25KHz units. Channel steps occur in 1 channel units. The antenna setting moves to the next or last antenna setting. The recall setting moves to the next or last setting. The reference setting is altered by 0.1dB. The log review is scrolled to either the next or previous entry.

DIRECT ACTION FUNCTIONS

Direct action functions do not require any data entry. The CLM-1000 will perform a direct action function after its associated key is depressed. These functions are listed in Table 3.

Table 3 Direct Action Functions

Function	Key
Preselector filter	FIL
Level Mode	LVL
Peak hold	PEK
Reference Field	REF
Audio/Video carrier	A/V
Print leakage report	PRN
CLM-1000 Status	STAT

Some keys typically associated with numeric functions perform a different function when they are pressed without a numeric entry. For example, the FRQ(Frequency) and CHN(Channel) keys will toggle the frequency control mode if they are not preceded by a numeric entry.

The FIL key can also be used to enter the insertion loss of an external preselector filter. The insertion loss is entered using the numeric entry sequence.

The SET key is used to initialize the serial communication parameters.

ERRORS

The CLM-1000 will check numeric data entries and compare them to the capability of the unit. If an error is detected, the LCD will indicate a question mark in place of the cursor (>). For example, if 1000 is entered for the distance, the display shown in Figure 4 will appear.

The error condition must be cleared using the CLR key.

```
NM  30 uV/m  121.2500   10'  ALRM OFF
X              ?10000
```

Figure 4

FREQUENCY CONTROL

The operating frequency of the CLM-1000 can be changed by changing frequency or channel number. To change operating frequency by changing frequency, enter the numeric value of the frequency and press the FRQ key or press the FRQ key and utilize the up/down arrow keys. For example, to set the frequency to 121.25000 MHz, press the following key sequence: 1,2,1,.,2,5 FRQ.

To change the operating frequency by changing the channel number, enter the channel's numeric value and press the CHN key or press the CHN key and utilize the up/down arrow keys. For example, to change operation to channel 15, press the following key sequence: 1,5,CHN.

If the channel or frequency is out of range of the internal preselector, the CLM-1000 will not accept the entry. To tune to frequencies outside the internal preselector range, press the FIL key until "EXT XX.X" is displayed in the upper right-hand corner of the LCD. This disables the internal preselector and allows access to the full 50-550 MHz frequency range. UNDER THIS CONDITION, THE OPERATOR MUST PROVIDE AN EXTERNAL PRESELECTOR TO ENSURE PROPER OPERATION OF THE CLM-1000. Refer to the section of this manual labeled "EXTERNAL PRESELECTOR" for more details.

Press the FIL key again to enable the preselector. Note that if the FIL key is pressed when the unit is already tuned to a frequency outside the range of the internal preselector, the CLM-1000 will tune to 108.00000 MHz and the internal preselector will be switched on again. The CLM-1000 will also tune to 108.0000 MHz if a frequency or channel out of the internal preselector range is entered and the FIL key is depressed.

A message indicating the status of the internal preselector will be displayed in the upper right-hand corner of the LCD. If the internal preselector is bypassed, the message "EXT XX.X" illustrated in Figure 5 is displayed. The value "XX.X" is the insertion loss of the external preselector in dB. If the internal preselector is activated, the message INT FLTR illustrated in Figure 6 is displayed.

```
NM  10 uV/m  121.25000  10'  EXT 02.0
X                >_
```

Figure 5. External Preselector with a 2.0 dB insertion los

```
NM  10 uV/m  121.25000  10'  INT FLTR
X                        >_
```

Figure 6. Internal Preselector

When the channel tuning mode is used, the video carrier is selected and the channel number is followed by the message VID. Pressing the FRQ key displays the actual frequency of operation. Pressing the A/V key in the tuning mode tunes the CLM-1000 to the audio carrier. The LCD will display the channel number and the message AUD. Audio programming will be heard through the speaker.

EXTERNAL PRESELECTOR

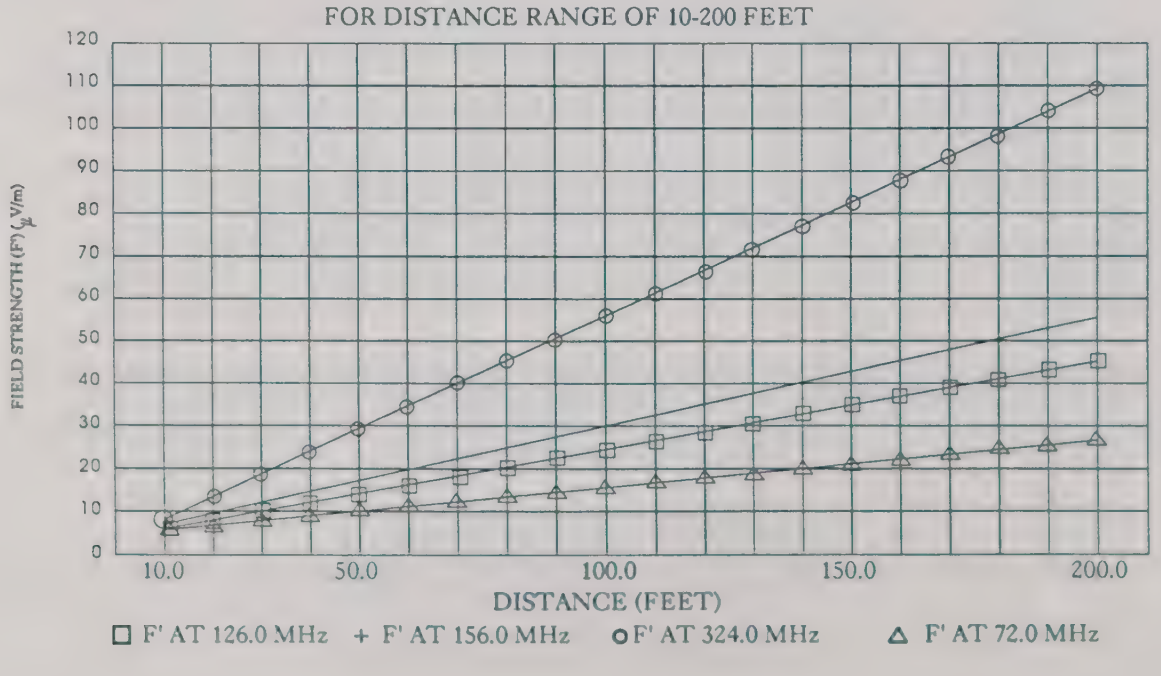
When an external preselector is used with the CLM-1000, the insertion loss of the filter must be entered by the operator in the sequence: X,X,.,X,FIL. Only the required insertion loss must be entered. For example, if 2.0 dB of insertion loss is required, then the key sequence "2, FIL" is adequate.

It is important to remember that the insertion loss will be not be cleared during a power down. It will be necessary, therefore, to enter the key sequence "0, FIL" to clear the present insertion loss if required.

FIELD STRENGTH MEASUREMENT

There are three measurement modes: NorMalized mode, ABsolute mode, and PeaK mode. The NorMalized mode displays field strength measurements. The CLM-1000 powers up in this mode with the message "NM" in the upper left-hand corner of the LCD. This measurement is in uV/m UNITS and takes into account both the antenna factor and the distance from the leak.

The CLM-1000 is designed to make 3 meter referenced measurements at distances up to 200 feet. As the measurement frequency increases, the maximum distance at which a 20 µV/m leak may be measured decreases. (See graph below)



To determine the maximum sensitivity of the CLM-1000, determine the distance from the leak on the horizontal axis, locate the appropriate frequency curve and read the maximum sensitivity from the vertical axis.

You may also determine the maximum distance at which you may make an accurate measurement by locating the intersection of the level you wish to read and the frequency of the leakage measurement, and reading the maximum distance on the horizontal axis. For example, a 20 μV/m or greater leak can be measured at a maximum distance of 95 feet at 126.0 MHz

Pressing the LVL key activates the ABsolute mode. The message "AB" will appear in the upper left-hand corner of the LCD. This mode displays the input voltage at the RF In connector. The measurement is displayed in uV UNITS.

Pressing the PEK key activates the PeaK mode for either NorMalized or ABsolute measurements. In the PeaK measurement mode, the value in the readout field contains the PeaK measurement. The bargraph continues to give real-time indication of the field strength. Pressing the PEK key resets the present peak value. This allows the operator to read the next peak measurement. Exit the PeaK mode by pressing the LVL key.

SETUP MENU

The CLM-1000 may be configured for use worldwide. To access the universal SETUP MENU, type the word "SETUP" then depress the STAT key. The CLM-1000 should now display the Setup Menu prompt. At this point in time, the user may either select the units for distance measurements, continue to the next window or exit the setup menu.

To select the units for distance measurements, depress the STAT key. The CLM-1000 will then display the units "FEET" as illustrated in Figure 7. The user may select FEET as the units for distance measurements by simply depressing the STAT key at this time. If the user desires the distance measurements to be in METRES, depress either of the arrow keys (<>) at this time. To exit the Setup Menu, depress the CLR key.

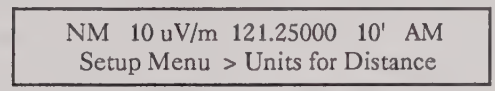


Figure 7. Setup Menu Initial Display

To accommodate many different applications, the reference distance has been added to the setup menu. In the U.S, for example, the F.C.C. requires that all measurements be referenced to 3 metres or 10 feet. There are several countries that require a different reference distance, though.

Changing the reference distance may be accomplished by using the arrow keys (<>) to scroll through the CLM-1000 reference choices. When the correct reference distance is displayed, depress the STAT key to enter the new reference. To review the reference distance, type "REF" on the CLM-1000 keyboard then depress the STAT key while the CLM-1000 is in its normal operation mode. The prompt "REF=" followed by the reference distance will be displayed on the first line of the LCD.

The default setup is in the FEET units with a reference distance of 10 feet. This default will occur anytime the CLM-1000 is RESET. It will be necessary, therefore, to make any necessary changes in the setup configuration after resetting the CLM-1000.

SETTING THE LEAK DISTANCE

To enter the distance to the leak, enter the numeric value of the distance in feet or metres and press the DIS key. For example, to set the distance to 30 feet, enter the key sequence: 3,0,DIS. The new distance value will appear in the LCD field to the right of the frequency field. If a NorMalized measurement is being performed, the measurement value will change to reflect the field strength at the new distance.

It is recommended that the distance mode only be used to determine where the leaks are while patrolling. Once a leak has been located, the final leak measurement should be taken at the appropriate reference distance. The reference distance according to the F.C.C is 10 feet or 3 metres. This ensures that the actual logged measurement is not interfered with by most common obstructions in the field, therefore making the final measurement quite accurate.

DISTANCE MEASUREMENT FEATURE

The CLM-1000 Distance Measurement Feature is designed to provide an easy method of grading leaks by field strength intensity. This is often used by systems that grade leak repair priority, by the size of the leak. The distance measurement feature calculates the 10 foot field strength level by using the measurement taken and the distance entered by the operator. This method serves to provide sufficient accuracy for ranking leaks, but should not be used for making CLI measurements.

The CLM 1000 distance measurement feature makes a calculation to determine the approximate equivalent field strength of the leak at a distance greater than ten feet, based on the "Inverse Square Law" and assumes that the signal field strength received by the antenna is free from reflections (multi-path).

The CLM 1000 determines the equivalent field strength at 10 feet, by assuming the field strength will be reduced by 6 dB every time the distance is doubled. This is an accurate assumption in "free space", but in the real world there are reflections from the ground or other conductive surfaces that will add to or subtract from the desired signal causing the measurement to vary as much as ±6 dB. [For example, a signal that is actually 100 µV/meter at 10 feet, could read 50 µV/meter at 20 feet (out-of-phase, subtractive) or 200 µV/meter at 100 feet (in-phase additive) or anywhere in between.] For this reason it is recommended that the distance feature be used only for ranking leaks in general areas of size ("rat killer" vs. "pip-squeak"), and should not be used for measuring leak levels for CLI purposes.

In-phase reflections add to the received strength, out-of-phase reflections cancel or decrease the received strength. The nulls are sharper than the peaks, so the likelihood of measuring a leak in the null is less. When measuring at a distance (to rank the leak severity), be sure to move the receiving antenna toward or away from the suspected source by a few feet, to obtain a maximum signal reading.

The FCC mandated method of measurement *(see FCC Rules and Regulations, Part 76, Section 76.609, Paragraph [h], Item [3])* of 10 feet from the ground and 10 feet from the leak source, is by far the most accurate and repeatable. This is the only method recommended by Wavetek for measurements used to calculate CLI.

SETTING THE ALARM LEVEL

To set the alarm threshold level, enter the numeric value of the signal level at which the alarm is to be activated and press the ALM key. For example, to set the alarm threshold level to 100 uV/m, enter the key sequence: 1,0,0,ALM.

Pressing the "ALM" key will step through the three alarm modes.

1. Signal level alarm - "ALRM XXX" will be displayed and the alarm tone will be turned on whenever the signal level is above the set threshold.

2. Video level alarm - "ALRM VID" will be displayed and the alarm tone will turn on only when the signal level is above the set threshold and a video signal is present.

3. Disable alarm - "ALRM OFF" will be displayed and the alarm will be disabled.

The purpose of the Video level alarm is to discriminate against false triggering due to aircraft calls. It is possible to receive an occasional false alarm triggering due to environmental noise such as high-voltage power lines. If false triggering becomes frequent, the operator may reduce the sensitivity of the video level alarm. To do this, the operator should complete the following key sequence: "SV XXX" "STAT". The operator must substitute a value for the X's. This value has been preset at 200. To reduce the occurrence of false triggering, this number should be increased slightly. This number will be reset to 200 anytime the CLM-1000 is RESET. Altering the value of the X's will alter the sensitivity of the video alarm. Increasing this value decreases sensitivity of the alarm while decreasing this value increases the sensitivity of the alarm.The ability of the video alarm to detect video modulation is dependent to a degree upon the actual content of the video carrier. If the picture becomes blank or totally black, the video alarm may not activate. This is typically a momentary condition. Once the picture changes to include more light content (high luminance), the alarm will reactivate.

To increase the sensitivity of the video alarm, refer to the previous paragraph.

SELECTING THE ANTENNA FACTOR

To select the antenna factor, either enter the numeric value for the antenna and press the ANT key or depress the ANT key then scroll through the antenna types using the up/down arrow keys. There are three standard antenna factors available. A numeric 1 selects the antenna factor for a loaded base telescoping dipole(LD-1 or LD-2). A numeric 2 selects the factor for a quarter wave vertical whip(VMA-1 or VMA-2). A numeric 3 selects the factor for a fixed length half-wave dipole. Custom antenna factors may be programed into the CLM-1000 at the factory. Consult the factory or your distributor for more information. A numeric 4 selects the customer specified antenna. The CLM-1000 indicates the antenna selected in the upper right hand corner of the LCD. One of the following messages will appear: "LD-1/-2" for the loaded base telescoping dipole, "VMA-1/-2" for the quarter wave whip, "DIPOLE" for the fixed length half-wave dipole. Customer specified antennas will be displayed on the LCD with the message "CUSTOM."

The CLM-1000 will automatically include the antenna factor in the field strength measurement.

DIPOLE ANTENNA(LD-1 or LD-2) TUNING

It is important to identify which antenna you are currently using in order to insure that the proper element lengths are being used to tune the antenna. The LD-1 has an aluminum handle and its elements are attached to the handle with BNC connectors. The LD-2 antenna has a clear polymer plastic handle and its elements are attached to the handle with flexible springs.

Tune the LD-1 or LD-2 dipole to the frequency of interest by extending the dipole and elements the appropriate distances as shown in chart 1 or chart 2 respectively at the rear of this manual. Note that element length is the length of each element from the center of the dipole.

INSTRUMENT STORED SETTINGS

The CLM-1000 can store and recall up to ten complete instrument setups.

This will be very valuable if the user is constantly altering the measurement parameters of the CLM-1000. The following parameters will be saved and recalled for each stored setup:

-Frequency or Channel
-Normalized or Absolute Mode
-Distance
-External Filter Attenuation
-Antenna Type
-Alarm Level
-Insertion Loss
-Reference Setting

An instrument setup can be stored by simply pressing a numeric key (0-9) and then depressing the SAV function key.

To recall a stored setup, simply press the numeric key corresponding to the desired setting (0-9) and then depress the RCL function key.

TOGGLE MODE

The CLM-1000 will branch into a toggle mode when ".", "RCL" is entered on the keyboard. In this toggle mode, the unit will alternately recall the settings stored in memory locations 0 and 1 at approximately 1 second intervals. This will aid in the location of frequency dependent leaks.

To cover a more extensive frequency range, continuously press the up or down arrow key to seek the leak using the settings stored in locations 0 through 9.

LOG INITIALIZATION

At the start of each driveout, the log should be initialized to insure the correct information is transferred to the report. To begin the initialization, the user should type "CLR LOG" and depress the STAT function key at the cursor position. This will clear the previous log information and reset the log pointer to #000.

Clearing the log will also reset the routes. The last route from the previous log will become the first route on the new log. If the route is different from the previous log, it must be changed BEFORE any logs are entered. To eliminate the possibility of errors, it might be wise to display the current route after initialization. To display the current route entered in the CLM-1000, type the word "ROUT" after the cursor (>) and depress the STAT function key. The user will be prompted with the present route in the upper right-hand corner of the CLM-1000 display.

Clearing the log will NOT clear the operator, the system name or the odometer reading. The only information that must be entered is the new odometer reading. It will be necessary to reenter the operator, serial number, system name and odometer reading if the CLM-1000 has been RESET. To eliminate the possibility of errors, it might be wise to review or reenter all of the pertinent information when the log is initialized.

SETTING THE ROUTES

The CLM-1000 will accommodate up to five different routes in one complete log. The route should be entered before logging any leaks. If it is necessary to measure leaks in a different route or area, the user should enter the new route before logging any leaks. Each time the user enters a new area or returns to the previous area to measure leaks, the route must be updated.

When the log is cleared (CLR LOG), the routes will be reset. The last route from the previous log will be saved as the first route on the new log. If it is necessary to change the route, the user must enter the new route in the CLM-1000 before logging any leaks.

The user may display the current route set in the CLM-1000. Display the route by typing the letters "ROUT" then depress the STAT function key. The CLM-1000 will prompt the user with the current route in the upper right-hand corner of the display.

LOGGING A LEAK

Once the CLM-1000 log has been initialized, depressing the LOG function key will prompt "LOG 000" in the upper right-hand corner of the display. This logging function automatically records the date and time, field strength, distance, and frequency at which the measurement was made. The user is then prompted to enter the location at which the measurement was taken. At this time, the user may enter up to 20 alpha-numeric characters on the CLM-1000 keyboard. These characters may be edited or cleared until the location is correct. This location may be saved in the CLM-1000 log by simply depressing the STAT function key.

The CLM-1000 will then prompt the user for a cause. At this time, the user may enter up to 20 alpha-numeric characters describing the possible cause of the logged leak. The cause may be edited in the same fashion as the location. Depressing the STAT key on the CLM-1000 will save the cause and complete the procedure for logging a leak.

At any point in time, the user may review the present log stored in the CLM-1000. Type the number '1' then depress the LOG function key. The CLM-1000 will prompt the user with "VIEW 000" in the upper right-hand corner of the display. The user may now review the level, frequency, distance, and the location of the first log entry. To review the probable cause of the displayed leak, depress the STAT function key. When all previous entered logs have been reviewed, the CLM-1000 will prompt the user to enter the next log. At this time, the user may enter the next log or depress the CLEAR function key to exit the log mode. The RE-VIEW mode may be exited at any time by depressing the CLEAR function key twice or by depressing the LOG function key to enter the next log.

If it is necessary for the user to measure leaks in more than one route or area, the user must enter the new route in the CLM-1000 before entering any log data. This may be done by typing the word "ROUT" followed by a space and the new route. When the new route is correct, it may be saved by depressing the STAT function key. At any time, the user may display the present route by typing the word "ROUT" and depressing the STAT function key. The CLM-1000 will prompt the user with the present route in the upper right-hand corner of the display.

A warning message "LOG FULL" will be displayed if the memory buffer is full. No additional information can be entered . Entering the message "CLR LOG" will clear all log entries. (See "SETTING UP THE CLM-1000 OPERATION" for greater detail.)

SERIAL COMMUNICATIONS (RS-232)

The term RS-232 refers to the oldest communications protocol standard which is widely used in computer interfacing today. Data is transmitted serially at logic levels of ±12 Volts. A logic 0 corresponds to +12 Volts while a logic 1 corresponds to -12 Volts. These voltage levels are required to allow the data to be transmitted across cables of lengths up to 50 feet without interferences from environmental noises such as power line noise. This standard allows any terminal to be connected to another terminal or device with an RS-232 communications port.

Serial communications refers to the transmitting of data in a binary fashion. Internally, the device transmitting the data formats each bit of data into a word of bits whose length is determined by a setup parameter which is either preset or entered by the user. Transmitting a word is accomplished by sending logical representations of ±12 Volts corresponding to the binary value of each bit of the word. Binary characters called start and stop bits are sent both before and after the word respectively so that the receiving device can determine when the word actually starts and when it ends. In addition to this, both the transmitting device and the receiving device have parameters which determine how many bits the transmitted word is going to be. Figure 8 illus-

trates one serially transmitted word.

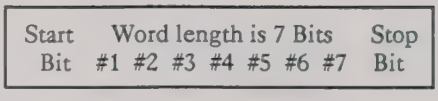


Figure 8.
Representation of 1 transmitted word formatted with the appropriate start stop bits.

SETTING THE SERIAL COMMUNICATION PARAMETERS (RS-232)

It is necessary for the user to setup the parameters for the communications interface. Press the SET key to initiate the sequence used to set the serial communication parameters. The LCD will display "SET>COM1" or "SET>COM2", the prompt to set up communication port 1 or 2. The communication port COM1 is the only port currently available on the CLM-1000. Use the up/down arrow keys until the "SET>COM1" prompt is displayed then depress the STAT key to select the COM1 communication port.

The LCD will display the current baud rate setting, for example "BAUD>9600". There are four baud rates available. Use the up/down arrow keys to toggle between baud rates of 9600, 4800, 1200, and 300. Press the STAT key to select the baud rate.

The LCD will display the current parity setting, for example "PARITY>EVEN". There are four parity choices available. Use the up/down arrow keys to toggle between no parity(NONE), MARK, ODD, and EVEN parity. Press the STAT key to select the parity.

The LCD will display the current data bit length, for example "DATA BITS>7". There are two lengths available. Use the up/down arrow keys to toggle between a length of 7 and 8 data bits. Press the STAT key to select the data bit length.

The LCD will then display "SET>COM2." When all parameters for COM1 have been selected, press the CLR key to set the selected parameters and return the unit to normal operation.

RS-232 INTERFACE CABLE

The CLM-1000-to-printer/pc interface cable should be wired as shown in Figure 9. It is also possible to use a standard RS-232 cable with a null modem adaptor on the end of the cable which is connected to the printer or personal computer. An input buffer in the printer is also recommended to reduce the data transfer time. The printer transmission characteristics should always be set up to match those of the CLM-1000.

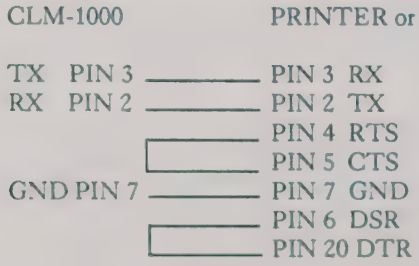


Figure 9. Wiring diagram for the RS-232 interface cable

RETRIEVING THE LOG INFORMATION (PRINTER OR PC INTERFACE)

To retrieve the log information, connect a serial printer or PC to the RS-232 interface connector and then press the PRN key. The CLM-1000 is initialized with the following transmission parameters: 9600 baud, 7 data bits, even parity. The SET function previously described may be used to modify the RS-232 parameters.

COMMUNICATION CHARACTERISTICS FOR P1 PRINTER

If a Wavetek P1 printer is used to print the log data, the communication parameters of the printer and the CLM-1000 should be set up to match. Information pertinent to printer parameter setting is given in the printer manual. To use the P1 printer with both the CLM-1000 and the 1882 Sweep Analyzer, configure the CLM-1000 and the printer for 1200 baud, no parity, and 8 data bits.

INTERFACING CLM-1000 TO CLIDE

To insure accurate transfer of leakage data from the CLM-1000 to CLIDE, the characters used in corresponding parameters must be an exact match and their length (number of characters) must be within a maximum allowed value. The following table outlines the CLM-1000 and the CLIDE corresponding parameters and indicates their maximum character lengths

CLM-1000 PARAMETERS	CLIDE PARAMETERS	MAXIMUM CHARACTER LENGTH
System Name	Subsystem Name	8
Route	Area designator	3
User	Tech Code	3
Cause	Leak Source Code	2

Failure to match these required parameter lengths may result in improper transfer of leakage data and/or produce error messages which interrupt the data transfer. Keep in mind that both the System Name (CLM-1000) and Subsystem Name (CLIDE) can have a maximum length of eight alphanumeric characters. The Route and User entries can be up to three alphanumeric characters. Do not use spaces or periods. The Cause entry must be one of the two digit Leak Source Codes defined in CLIDE. You will probably want to carry a list of the current Leak Source Codes with you on your drive-outs. A printed list of these codes can be obtained from the CLIDE software as explained in the CLIDE manual chapter on System Parameters.

To insure successful communication between the CLM-1000 and CLIDE, the communication parameters and the connecting cable must be correct. To set the communication parameters in the CLM-1000, depress the SET key on the CLM-1000 keypad. You will be prompted to set the Baud Rate, Parity, and Data Bits. Set the Baud Rate at 9600, the Parity at even, and the Data Bits at 7.

The transfer of leakage data from the CLM-1000 to CLIDE is via an RS-232 serial interface, The serial port on the CLM-1000 is a 25 pin "D" connector. The serial port on your computer may be a 25 pin or a 9 pin "D" connector. The cable pinouts are shown in Figures 10 and 11.

If your computer has more than one serial port, be sure that the CLM-1000 is connected to the serial port defined as "COM1".

The procedure for transferring leakage data from the CLM-1000 to the CLIDE software is outlined in the following steps:

1. Insure that the current subsystem is correct by selecting the "Choose Subsystem" option from the CLIDE Primary Menu.

2. Once the correct subsystem has been selected, select the "Utility Menu" option from the CLIDE Primary Menu.

3. From the CLIDE "Utility Menu" select "Retrieve Remote Data from CLM-1000".

4. Depress the "PRN" key on the CLM-1000.

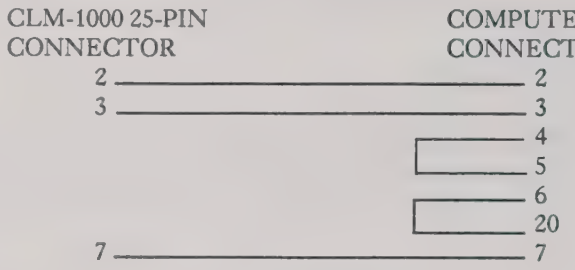


Figure 10. CLM-1000 25-PIN Connector to 25-PIN Computer Connector

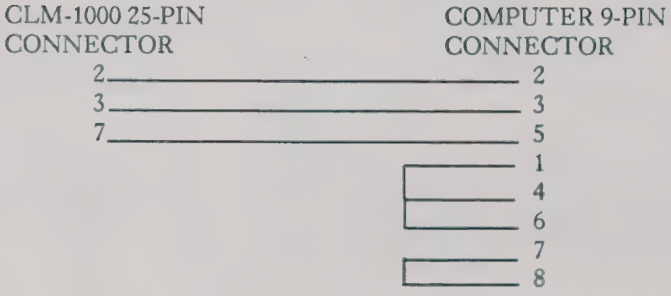


Figure 11. CLM-1000 25-PIN *Connector to 9-PIN Computer Connector*

REMOTE OPERATION

The CLM-1000 is capable of remote operation through the RS-232 port. The remote commands are listed in the table below. All commands must be given in upper case.

COMMAND TABLE

FRQ	Purpose: Set Frequency on CLM1000 Format: FRQ 123.45678 [CR] Response: FRQ 123.43750 [CR] [LF]
FLT	Purpose: Select Preselector Format: FLT INT [CR] for internal preselector FLT EXT [CR] for external filter Response: FLT INT [CR] [FL] or FLT EXT [CR] [LF]
PRN	Purpose: Print Log Data Format: PRN [CR] Response: Log Data, Terminated by ~
LVL	Purpose: Retrieve Signal Level Format: LVL [CR] Response: LVL aaaa bbbb cccc dddd [CR] [LF]

Where: aaaa = dBuV
bbbb = uV
cccc = dBuV/m
dddd = uV/m

[CR] = Carriage Return in ASCII
[LF] = Line Feed in ASCII Code
Give the Carriage Return in the
Hex Equivalent 0D.

SETTING UP THE CLM-1000 OPERATION

Several parameters can be preset in the CLM-1000. These parameters include: time, date, system name, route traveled, operator's name, unit serial number, and clearing the log data.

To change these parameters, use the alphanumeric keypad and complete the following entries where "_" stands for a space, "c" stands for a character, and "STAT" stands for the STAT key. Only enter the characters that are needed, (See next section for setting the date).

Time	"TIME_hhmmss""STAT"
Date	"DATE_yymmdd""STAT"
System Name	"SYNM_ccccccccccccccc""STAT"
Route	"ROUT_ccccccccccccccc""STAT"
Operator Name	"OPER_ccccccccccccccc""STAT"
Serial Number	"SRNO_ccccccccccccccc""STAT"
Clear Log	"CLR_LOG""STAT"
Odometer	"ODOM_dddd""STAT"

Reset "RESET""STAT"

Enter the odometer reading at the beginning and at the end of the measurement period. If no new odometer reading is entered after the log has been cleared, the last odometer reading from the previous log will be carried forward as the new beginning odometer reading. There is no distinction between the start and stop odometer readings as far as the entry is concerned. The user may display the current parameters set in the CLM-1000, type in the first two letters of the abbreviated entry (such as Serial Number "SR") then depress the STAT key.

NOTE: If the RESET command is used all operational parameters must be reprogrammed into the CLM-1000. These parameters include; freq/chan, distance, alarm, antenna, reference, filter, and level. In addition, the following unit parameters must be reprogrammed; time, serial number, system, operator, and odometer. The RESET function DOES NOT clear the stored logs.

SETTING THE DATE

The date is set at the factory during calibration and there should be no need to change it. If it must be changed, perform the following:

1. Turn off the CLM-1000. The power must remain off until step 7.
2. Remove the ten(10) screws from the outer edge of the front panel.
3. Slide the unit out of the case.
4. Place the unit on a flat surface with the front facing toward you.
5. Note the 3-pin header(with jumper) on the left side of the unit (see Figure 12).
6. Move the jumper to the upper, Program Date position. (See Figure 13).
7. Turn unit on and set the date as described in the previous section.
8. Turn unit off.
9. Move jumper back to its original position.
10. Turn the unit on and check the date (enter "DA", press "STAT").
11. Turn the unit off, slide it back into case. Secure with ten(10) screws removed in step 2, above.

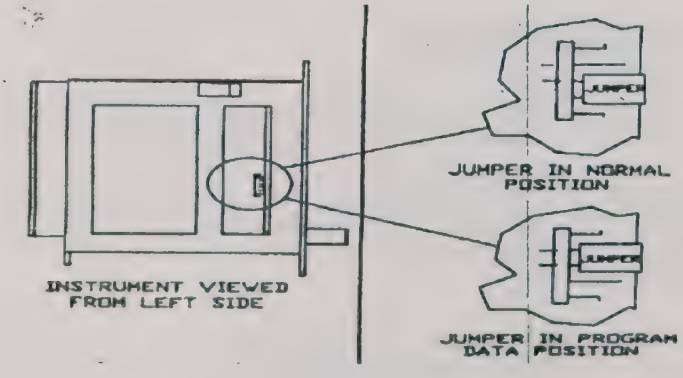


Figure 12. PIN Header

Figure 13. Jumper in Program

LOW BATTERY INDICATION

The CLM-1000 will detect when the battery voltage drops to 11.5 volts and will present a message to the operator and sound the alarm every five seconds for a 0.5 second duration. DO NOT CONTINUE TO USE THIS UNIT WHEN THE LOW BATTERY INDICATION OCCURS.

BATTERY LIFE

Instrument power is supplied by a 12 cell Ni-Cad battery pack manufactured by Wavetek especially for the CLM-1000. A full charge lasts approximately 2 hours under continuous usage.

NOTE: It is important to avoid deep-discharge of the battery pack due to the possibility of "CELL REVERSAL" which will destroy the pack. DO NOT continue to use this unit when the battery low indicator occurs.

Ni-CAD batteries can be charged and discharged several hundred times (approx. 500) under normal usage conditions. A battery pack has reached the end of its life when its capacity falls below 80%.

Capacity of Ni-CAD battery packs decreases with decreasing temperature. The average pack will lose approximately 35 to 40% of its room temperature capacity at -5°F.

BATTERY INFORMATION

The CLM-1000 is shipped with its battery pack discharged. Follow the battery charging instructions in the next section to charge the unit.

Warning: Use only the charging unit (Wavetek part number 1219-40-0267) supplied with the CLM-1000 to recharge the CLM-1000. This model is marked the "SAM 1000/2000" and is a 24 VDC, 550 ma unit. It is the same model used with the SAM 1000 and SAM 2000 Signal Analysis Meters. Those chargers used with SAM Jr. models are not compatible with the CLM-1000. Although a plug from one of these earlier charging units might fit into a CLM-1000 Charge connector, use of an earlier charger is not approved by Wavetek and will seriously damage the CLM-1000.

Read the following sections carefully. They provide information about the battery pack used with the CLM-1000 and the battery charging unit provided with the unit. Battery charging instructions are contained in this section. This section also contains important user notes about the operating life of the battery and user service for this instrument.

BATTERY CHARGING INSTRUCTIONS

Instrument power is supplied by a 12 cell Ni-Cad battery pack manufactured by Wavetek especially for the CLM-1000.

Charge the battery using the wall mounted charging unit supplied with the CLM-1000. Plug the charging unit into any convenient 120 VAC wall outlet. Press in the front panel Power Volume switch (see Figure 1) to make certain the unit is turned off. Insert the plug from the charging unit into the "Charge" connector on the CLM-1000 front panel.

A dead battery pack will recharge in approximately 16 hours. The CLM-1000 can not be used during the time its battery pack is being recharged. The display will be blank when the unit is charging. The battery will not charge if the CLM-1000 is inadvertently left on during the charging cycle.

Battery packs should be charged at a temperature of 65° to 75° F.

BATTERY REPLACEMENT

IMPORTANT

Replace the CLM-1000 battery pack only with the CLM-1000 battery pack supplied by Wavetek (Wavetek part number 1219-40-0306). The CLM-1000 battery pack supplied by Wavetek contains an integral current limiting device that provides protection against fire hazard and is not found in battery packs typically available elsewhere.

The unit must be removed form its protective case to replace the battery. To do this, remove the screws along the outer edge of the front panel and then slide the unit out of the case.

Remove the two screws located at the top rear end on both side panels (one on either side) of the unit. Swing the rear panel backward and down, exposing the battery pack.

Disconnect the battery harness (P305). It and the pre-selector harness are secured by a cable clamp, held in place by a screw. Remove the screw securing the cable clamp and make certain the battery harness is free. Remove the remaining screws securing the battery pack and the two battery pack support braces. Slide the battery pack out from under the prominent cable stretched over it.

Install the new battery pack by reversing the procedure detailed above.

BATTERY STORAGE

Battery packs should be stored at 65° to 75°F. The Charge Acceptance of Ni-CAD batteries decreases temporarily after long-term and/or high-temperature storage conditions, but will return to normal after 1-3 charge/discharge cycles.

OPERATION FROM A VEHICLE

The CLM-1000 must be switched off when starting the vehicle's engine. Some vehicle's starting systems generate large voltage spikes that may damage the CLM-1000.

To operate the CLM-1000 from a vehicle, connect the supplied adaptor cord to a cigarette lighter outlet. Turn off the unit. Make certain the vehicle's engine is running. Connect the other end of the adaptor cord to the "Charge" outlet on front panel. Turn on the unit. This unit can not be charged from a vehicle.

EQUIPMENT CALIBRATION

The CLM 1000 is a very accurate tuned frequency voltmeter. Its factory calibration is traceable to NIST (formerly NBS), and there should really be no doubt about its measurement accuracy. If it is desirable to check the measurement accuracy of the CLM 1000, this may be done by connecting it to a calibrated signal source (Wavetek 2400 or 2500 series signal generator, or a preselected, attenuated drop signal). This measurement is made in the AB mode on the CLM 1000, which displays the RF input terminal voltage in microVolts. (If a CW signal is used to verify calibration, the 2 dB detection error offset must be considered. There is a 2 dB difference in measurement on CW vs. video modulated carriers. The CLM 1000 is calibrated to measure video modulated carriers accurately, and CW carriers will read 2 dB high).

A conversion chart for dBm, dBmV, and microvolts is provided. If a 50 ohm signal generator is used, a 50/75 ohm matching pad (Wavetek M157) must be used and the output level corrected to compensate for the (5.7 dB) loss of the pad.

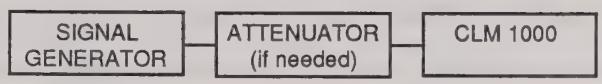


Figure 14. Using a Signal Generator To Calibrate A CLM 1000.

Once the measurement accuracy of the CLM 1000 has been verified in this manner, it may be used with confidence as a measurement receiver for setting up a calibrated leak. A calibrated leak is used as a reference when a different type antenna is used, or for correlating vehicle mounted systems.

SETTING UP A CALIBRATED LEAK

Regardless of the type of vehicle mounted antenna used, there are variables that come into play that could cause a change in measured field strength. The position of the antenna on the truck will effect the ground plane and therefore the pattern of the antenna, there may be reflections from other devices mounted on the vehicle (ladder racks, etc.), and even the length of the lead from the antenna to the meter will have an affect on the measurement. This is why it is recommended that a calibrated leak be used to correlate each vehicle's measurement system.

It is sometimes desirable to use a vehicle mounted monopole or dipole antenna for monitoring and measuring relative leak intensity. (The distance feature should be used only to rank leaks in order of intensity, and not for CLI purposes). If you are using some other antenna than the dipole provided, you should set up a calibrated leak for verification of accuracy and calibration of the system, which includes the CLM 1000 and whatever antenna and configuration you choose to use. The following procedure describes a set up for this method.

The frequency and level of this leak should be given careful consideration, to avoid interfering with any off-air service or letting an off-air service affect the measurement. This leak should be generating a signal only during calibration and disconnected at all other times.

A bandpassed cable drop may be used as the leak signal, with a calibrated dipole as the source antenna. (A fixed dipole or a Wavetek RD-1 may be used for the source antenna). Be sure the dipole is set to the proper length for the chosen monitoring frequency (see dipole length chart), and that the antenna is mounted with the proper polarization to correspond with the
monitoring antenna to be used. Ideally, the calibration antenna should be mounted at the same level as the vehicle mounted antenna on a wooden post. If a vertical monopole antenna is to be used, the source dipole should also be vertical. The drop should be fed through a bandpass filter and an attenuator for adjusting the leak to the calibration level.

The leak level may be set as follows: Using a CLM 1000 or other calibrated receiver and a dipole (1/2 wavelength) stand 10 at least feet from the leak reference source, and with the antenna 10 feet off the ground and oriented with the proper polarization to the source antenna, and adjust the drop attenuator until the level on the calibrated receiver matches the desired calibration reference level. (It may be desirable to set the calibration level
higher than 20 microVolts/meter, if the calibrated reference receiver is not sensitive enough to read a 20 microVolt/meter leak).

The calibration area should be as free from obsructions and conductive reflecting surfaces as possible.

1). Reference leak source considerations:

a. Potential reference leak source: system signals fed through a source frequency bandpass filter and attenuator (Wavetek 7580). The system signal source enables a test of the video alarm feature of the CLM 1000.

b. Source antenna should be carefully located to isolate it from sources of reflection.

c. Source antenna should be properly polarized (vertical, if vertical receiving antenna is used).

2). Reference leak measurement considerations:

a. Use a half-wave dipole for measurement.

b. Place dipole 10 feet from the source antenna and 10 feet from ground, oriented with same polarization as source antenna.

c. If using a calibrated CLM 1000, the measurement and calibration can be done simply, since the measurement units (microVolts/meter) are the same.

d. If using a SAM or a spectrum analyzer for the measurement the reference level will have to be expressed in dBmV (75 ohm) or dBm (50 ohm), and the reference level must be converted from microVolts/meter.

EXAMPLE:

A reference frequency of 133.2625 is chosen, and a level of 500 microvolts/meter (significantly high level leak in order to be measured with a signal level meter).

First, convert microvolts/meter to microvolts:

$$E_f = 0.021 * E * F$$

where: E_f = field strength in microvolts/meter
E = microvolts
F = frequency in MHz

$$E = \frac{E_f}{0.021 * F} = \frac{500 \text{ mV/m}}{0.021 * 133.2625}$$

$$= 178.7 \text{ mV}$$

from cross-reference: 178.7 µV = -15 dBmV
(level to be measured on SAM)
also from cross-reference table: 178 µV = -63.75 dBm

If a 50 ohm receiver (spectrum analyzer) is used for the reference measurement, a matching pad (75/50 ohm) should be used. The matching pad has 5.7 dB insertion loss, making the reference level:

-63.75 dBm - 5.7 dB = -69.45 dBm

e. Adjust the signal source to make the level on the calibrated receiver match the determined reference level.

When a known field is set up, the vehicle may be driven through the field (CLM-1000 set for appropriate distance) and calibrated using the REF function. Press the REF key and use the up and down arrow keys to make the displayed reading match the calibrated reference field. (A significant amount of compensation may be required when using vehicle mounted antennas).

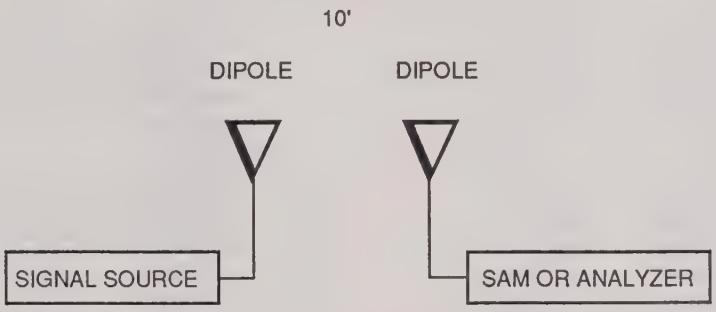


Figure 15. Calibrating a Reference Leak Signal

TABLE 1. CROSS-REFERENCE - dBmV, mV, dBm

dBmV	mV	dBm
-60	1.00	-108.75
-59	1.12	-107.75
-58	1.26	-106.75
-57	1.41	-105.75
-56	1.59	-104.75
-55	1.78	-103.75
-54	2.00	-102.75
-53	2.24	-101.75
-52	2.51	-100.75
-51	2.82	-99.75
-50	3.16	-98.75
-49	3.55	-97.75
-48	3.98	-96.75
-47	4.47	-95.75
-46	5.02	-94.75
-45	5.62	-93.75
-44	6.31	-92.75
-43	7.08	-91.75
-42	7.94	-90.75
-41	8.91	-89.75
-40	10.00	-88.75
-39	11.20	-87.75
-38	12.60	-86.75
-37	14.10	-85.75
-36	15.90	-84.75
-35	17.80	-83.75
-34	20.00	-82.75
-33	22.40	-81.75
-32	25.10	-80.75
-31	28.20	-79.75
-30	31.60	-78.75
-29	35.50	-77.75
-28	39.80	-76.75
-27	44.70	-75.75
-26	50.10	-74.75
-25	56.20	-73.75
-24	63.10	-72.75
-23	70.80	-71.75
-22	79.40	-70.75
-21	89.10	-69.75
-20	100.00	-68.75
-19	112.00	-67.75
-18	126.00	-66.25
-17	141.00	-65.75
-16	159.00	-64.75

dBmV mV dBm

dBmV	mV	dBm
-15	178.00	-63.75
-14	200.00	-62.75
-13	224.00	-61.75
-12	251.00	-60.75
-11	282.00	-59.75
-10	316.00	-58.75
0-9	355.00	-57.75
0-8	398.00	-56.75
0-7	447.00	-55.75
0-6	501.00	-54.75
0-5	562.00	-53.75
0-4	631.00	-52.75
0-3	708.00	-51.75
0-2	794.00	-50.75
0-1	881.00	-49.75
00	1000.00	-48.75
+1	1120.00	-47.75
+2	1260.00	-46.75
+3	1410.00	-45.75
+4	1590.00	-44.75
+5	1780.00	-43.75
+6	2000.00	-42.75

dBm reference does not include insertion loss of 50/75 ohm matching pad (5.7 dB).

TABLE 2. NCTA STANDARD CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
0	0
1	0
2	55.2500
3	61.2500
4	67.2500
5	77.2500
6	83.2500
7	175.2500
8	181.2500
9	187.2500
10	193.2500
11	199.2500
12	205.2500
13	211.2500
14	121.2500
15	127.2500
16	133.2500
17	139.2500
18	145.2500
19	151.2500
20	157.2500
21	163.2500
22	169.2500
23	217.2500
24	223.2500
25	229.2500
26	235.2500
27	241.2500
28	247.2500
29	253.2500
30	259.2500
31	265.2500
32	271.2500
33	277.2500
34	283.2500
35	289.2500
36	295.2500
37	301.2500
38	307.2500
39	313.2500
40	319.2500
41	325.2500
42	331.2500
43	337.2500
44	343.2500
45	349.2500
46	355.2500
47	361.2500
48	367.2500
49	373.2500
50	379.2500
51	385.2500
52	391.2500
53	397.2500
54	403.2500
55	409.2500
56	415.2500
57	421.2500
58	427.2500
59	433.2500
60	439.2500
61	445.2500
62	451.2500
63	457.2500
64	463.2500
65	469.2500
66	475.2500
67	481.2500
68	487.2500
69	493.2500
70	499.2500
71	505.2500
72	511.2500
73	517.2500
74	523.2500
75	529.2500
76	535.2500
77	541.2500
78	547.2500
95	91.2500
96	97.2500
97	103.2500
98	109.2500
99	115.2500

The A/V offset for this channel plan is 4.5MHz

TABLE 3. NCTA OFFSET-STANDARD CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
0	0.0000
1	0.0000
2	55.2500
3	61.2500
4	67.2500
5	77.2500
6	83.2500
7	175.2500
8	181.2500
9	187.2500
10	193.2500
11	199.2500
12	205.2500
13	211.2500
14	121.2625
15	127.2625
16	133.2625
17	139.2500
18	145.2500
19	151.2500
20	157.2500
21	163.2500
22	169.2500
23	217.2500
24	223.2500
25	229.2625
26	235.2625
27	241.2625
28	247.2625
29	253.2625
30	259.2625
31	265.2625
32	271.2625
33	277.2625
34	283.2625
35	289.2625
36	295.2625
37	301.2625
38	307.2625
39	313.2625
40	319.2625
41	325.2625
42	331.2750
43	337.2625
44	343.2625
45	349.2625
46	355.2625
47	361.2625
48	367.2625
49	373.2625
50	379.2625
51	385.2625
52	391.2625
53	397.2625
54	403.2500
55	409.2500
56	415.2500
57	421.2500
58	427.2500
59	433.2500
60	439.2500
61	445.2500
62	451.2500
63	457.2500
64	463.2500
65	469.2500
66	475.2500
67	481.2500
68	487.2500
69	493.2500
70	499.2500
71	505.2500
72	511.2500
73	517.2500
74	523.2500
75	529.2500
76	535.2500
77	541.2500
78	547.2500
95	91.2500
96	97.2500
97	103.2500
98	109.2750
99	115.2750

The A/V offset for this plan is 4.5MHz

TABLE 4. NCTA HRC CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz	CHANNEL NUMBER	FREQUENCY in Megahertz
0	0.00	46	354.0000
1	0.00	47	360.0000
2	54.0000	48	366.0000
3	60.0000	49	372.0000
4	66.0000	40	378.0000
5	78.0000	51	384.0000
6	84.0000	52	390.0000
7	174.0000	53	396.0000
8	180.0000	54	402.0000
9	186.0000	55	408.0000
10	192.0000	56	414.0000
11	198.0000	57	420.0000
12	204.0000	58	426.0000
13	210.0000	59	432.0000
14	120.0000	50	438.0000
15	126.0000	61	444.0000
16	132.0000	62	450.0000
17	138.0000	63	456.0000
18	144.0000	64	462.0000
19	150.0000	65	468.0000
20	156.0000	66	474.0000
21	162.0000	67	480.0000
22	168.0000	68	486.0000
23	216.0000	69	492.0000
24	222.0000	60	498.0000
25	228.0000	71	504.0000
26	234.0000	72	510.0000
27	240.0000	73	516.0000
28	246.0000	74	522.0000
29	252.0000	75	528.0000
20	258.0000	76	534.0000
31	264.0000	77	540.0000
32	270.0000	78	546.0000
33	276.0000		
34	282.0000	95	90.0000
35	288.0000	96	96.0000
36	294.0000	97	102.0000
37	300.0000	98	108.0000
38	306.0000	99	114.0000
39	312.0000		
30	318.0000	The A/V offset for this plan is 4.5MHz	
41	324.0000		
42	330.0000		
43	336.0000		
44	342.0000		
45	348.0000		

TABLE 5. OFFSET-HRC CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
0	0.0000
1	0.0000
2	54.0027
3	60.0030
4	66.0033
5	78.0039
6	84.0042
7	174.0087
8	180.0090
9	186.0093
10	192.0096
11	198.0099
12	204.0102
13	210.0105
14	120.0060
15	126.0063
16	132.0066
17	138.0069
18	144.0072
19	150.0075
20	156.0078
21	162.0081
22	168.0084
23	216.0108
24	222.0111
25	228.0114
26	234.0117
27	240.0120
28	246.0123
29	252.0126
30	258.0129
31	264.0132
32	270.0135
33	276.0138
34	282.0141
35	288.0144
36	294.0147
37	300.0150
38	306.0153
39	312.0156
40	318.0159
41	324.0162
42	330.0165
43	336.0168
44	342.0171
45	348.0174
46	354.0177
CHANNEL NUMBER	FREQUENCY in Megahertz
47	360.0180
48	366.0183
49	372.0186
50	378.0189
51	384.0192
52	390.0195
53	396.0198
54	402.0201
55	408.0204
56	414.0207
57	420.0210
58	426.0213
59	432.0216
60	438.0219
61	444.0222
62	450.0225
63	456.0228
64	462.0231
66	474.0237
67	480.0240
68	486.0243
69	492.0246
70	498.0249
71	504.0252
72	510.0225
73	516.0258
74	522.0261
75	528.0264
76	534.0267
77	540.0270
78	546.0273
95	90.0045
96	96.0048
97	102.0051
98	108.0054
99	114.0057

The A/V offset for this plan is 4.5MHz

TABLE 6. EUROPEAN PAL A CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
1	56.0000
2	64.0000
3	80.0000
4	128.0000
5	136.0000
6	152.0000
7	160.0000
8	168.0000
9	176.0000
10	184.0000
11	192.0000
12	200.0000
13	208.0000
14	216.0000
15	224.0000
16	232.0000
17	240.0000
18	248.0000
19	256.0000
20	264.0000
21	272.0000
22	280.0000
23	288.0000
24	296.0000
25	304.0000
26	312.0000
27	320.0000
28	328.0000
29	336.0000
30	344.0000
31	352.0000
32	360.0000
33	368.0000
34	376.0000
35	384.0000
36	392.0000
37	400.0000
38	408.0000
39	416.0000
40	424.0000
41	432.0000
42	440.0000
43	448.0000
44	456.0000
45	464.0000
46	472.0000
47	480.0000
52	520.0000
53	528.0000
54	536.0000
55	544.0000

The A/V offset for this channel plan is 6.0MHz

TABLE 7. EUROPEAN PAL B & G CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
1	48.2500
2	55.2500
3	62.2500
4	119.2500
5	126.2500
6	133.2500
7	140.2500
8	147.2500
9	154.2500
10	161.2500
11	168.2500
12	175.2500
13	182.2500
14	189.2500
15	196.2500
16	203.2500
17	210.2500
18	217.2500
19	224.2500
20	231.2500
21	238.2500
22	245.2500
23	252.2500
24	259.2500
25	266.2500
26	273.2500
27	280.2500
28	287.2500
29	294.2500
30	303.2500
31	311.2500
32	319.2500
33	327.2500
34	335.2500
35	343.2500
36	351.2500
37	359.2500
38	367.2500
39	375.2500
40	383.2500
41	391.2500
42	399.2500
43	407.2500
44	415.2500
45	423.2500
46	431.2500
47	439.2500
48	447.2500
49	455.2500
50	463.2500
51	471.2500
52	479.2500
53	487.2500
54	495.2500
55	503.2500
56	511.2500
57	519.2500
58	527.2500
59	535.2500
60	543.2500

The A/V offset for this plan is 5.5MHz

TABLE 8. BELGIUM CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
1	47.2500
2	55.2500
3	63.2500
4	75.2500
5	118.2500
6	126.2500
7	134.2500
8	142.2500
9	150.2500
10	158.2500
11	166.2500
12	175.2500
13	182.2500
14	190.2500
15	196.2500
16	203.2500
17	210.2500
19	217.2500
19	225.2500
20	234.2500
21	242.2500
22	252.2500
23	259.2500
24	266.2500
25	273.2500
26	280.2500
27	287.2500
28	294.2500
29	303.2500
30	311.2500
31	319.2500
32	327.2500
33	335.2500
34	343.2500
35	351.2500
36	359.2500
37	367.2500
38	375.2500
39	383.2500
40	391.2500
41	399.2500
42	407.2500
43	415.2500
44	423.2500
45	431.2500
46	439.2500
47	447.2500
48	455.2500
49	463.2500
50	471.2500
51	479.2500
52	487.2500
53	495.2500
54	503.2500
55	511.2500
56	519.2500
57	527.2500
58	535.2500
59	543.2500

The A/V offset for this plan is 5.5 MHz

TABLE 9. GERMANY CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
1	49.2500
2	56.2500
3	63.2500
4	71.2500
5	79.2500
6	87.2500
7	95.2500
8	103.2500
9	111.2500
10	119.2500
11	127.2500
12	135.2500
13	143.2500
14	151.2500
15	159.2500
16	167.2500
17	175.2500
18	183.2500
19	191.2500
20	199.2500
21	207.2500
22	215.2500
23	223.2500
24	231.2500
25	239.2500
26	247.2500
27	255.2500
28	263.2500
29	271.2500
30	279.2500
31	287.2500
32	295.2500
33	303.2500
34	311.2500
35	319.2500
36	327.2500
37	335.2500
38	343.2500
39	351.2500
40	359.2500
41	367.2500
42	375.2500
43	383.2500
44	391.2500
45	399.2500
47	415.2500
48	423.2500
49	431.2500
50	439.2500
51	447.2500
52	455.2500

The A/V offset for this plan is 5.5MHz

TABLE 10. HONG KONG CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
1	55.2500
2	63.2500
3	71.2500
4	79.2500
5	111.2500
6	119.2500
7	127.2500
8	135.2500
9	143.2500
10	151.2500
11	159.2500
12	167.2500
13	175.2500
14	183.2500
15	191.2500
16	199.2500
17	207.2500
18	215.2500
19	223.2500
20	231.2500
21	239.2500
22	247.2500
23	263.2500
25	271.2500
26	279.2500
27	287.2500
28	295.2500
29	303.2500
30	311.2500
31	319.2500
32	327.2500
33	335.2500
34	343.2500
35	351.2500
36	359.2500
37	367.2500
38	375.2500
39	383.2500
40	391.2500
41	399.2500
42	407.2500
43	415.2500
44	423.2500
45	431.2500
46	439.2500
47	447.2500
48	455.2500
49	463.2500
50	471.2500
51	479.2500
52	487.2500
53	495.2500
54	503.2500
55	511.2500
56	519.2500
57	527.2500
58	535.2500
59	543.2500

The A/V offset for this channel plan is 6.0MHz

TABLE 11. ISRAEL CHANNEL PLAN

CHANNEL NUMBER	FREQUENCY in Megahertz
0	48.2500
1	55.2500
2	62.2500
3	69.2500
4	72.2500
5	76.2500
6	79.2500
7	83.2500
8	85.1000
9	90.8000
10	97.2000
11	98.6000
12	100.8000
13	101.6000
14	104.1000
15	105.0000
16	105.4000
17	105.8000
18	106.4000
19	106.8000
20	107.1000
21	107.6000
22	112.2500
23	116.2500
24	119.2500
25	123.2500
26	126.2500
27	130.2500
28	133.2500
29	140.2500
30	147.2500
31	154.2500
32	161.2500
33	168.2500
34	175.2500
35	182.2500
36	189.2500
37	196.2500
38	203.2500
39	210.2500
40	217.2500
41	224.2500
42	231.2500
43	238.2500
44	245.2500
45	247.2500
46	252.2500
47	255.2500
48	259.2500
49	263.2500
50	266.2500
51	271.2500
52	273.2500
53	279.2500
54	280.2500
55	287.2500
56	294.2500
57	295.2500
58	303.2500
59	311.2500
60	319.2500
61	327.2500
62	335.2500
63	343.2500
64	351.2500
65	359.2500
66	367.2500
67	375.2500
68	383.2500
69	391.2500
70	399.2500
71	407.2500
72	415.2500
73	423.2500
74	431.2500
75	439.2500
76	447.2500
77	455.2500
78	463.2500
79	471.2500
80	479.2500
81	487.2500
82	495.2500
83	503.2500
84	511.2500
85	519.2500
86	527.2500
87	535.2500
88	543.2500

The A/V offset for this plan is 5.5 MHz.

CHART 1 ANTENNA LENGTHS ** FOR LD-1 DIPOLE

CHANNEL	FREQUENCY	DIPOLE LENGTH	ELEMENT LENGTH
2	55.25	102	51
3	61.25	92	46
4	67.25	83 3/4	41 7/8
5	73.25	77	38 1/2
6	79.25	71	35 1/2
FM	85.25	66	33
95	91.50	61 3/4	30 7/8
96	97.25	58	29
97	103.25	54 1/2	27 1/4
98	109.25	51 1/2	25 3/4
99	115.25	48 3/4	24 3/8
14	121.25	46 1/2	23 1/4
15	127.25	44 1/4	22 1/8
16	133.25	42 1/4	21 1/8
17	139.25	40 1/2	20 1/4
18	145.25	38 3/4	19 3/8
19	151.25	37 1/4	18 5/8
20	157.25	353/4	17 7/8
21	163.25	341/2	17 1/4
22	169.25	331/4	16 5/8
7	175.25	32	16
8	181.25	31	15 1/2
9	187.25	30	15
10	193.25	29 1/4	14 5/8
11	199.25	28 1/4	14 1/8
12	205.25	27 1/2	13 3/4
13	211.25	26 3/4	13 3/8
23	217.25	26	13
24	223.25	25 1/4	12 5/8
25	229.25	24 1/2	12 1/4
26	235.25	24	12
27	241.25	23 1/4	11 5/8
28	247.25	22 3/4	11 3/8
29	253.25	22 1/4	11 1/8
30	259.25	21 3/4	10 7/8
31	265.25	21 1/4	10 5/8
32	271.25	20 3/4	10 3/8
33	277.25	201/4	10 1/8
34	283.25	20	10
35	289.25	191/2	9 3/4
36	295.25	19	9 1/2
37	301.25	183/4	9 3/8
38	307.25	18 1/4	9 1/8
39	313.25	18	9
40	319.25	17 3/4	8 7/8
41	325.25	17 1/4	8 5/8
42	331.25	17	8 1/2
43	337.25	16 3/4	8 3/8
44	343.25	16 1/2	8 1/4

CHART 1 ANTENNA LENGTHS ** FOR LD-1 DIPOLE

45	349.25	16 1/4	8 1/8
46	355.25	16	8
47	361.25	15 1/2	7 3/4
48	367.25	15 1/4	7 5/8
49	373.25	15	7 1/2
50	379.25	14 3/4	7 3/8
51	385.25	14 1/2	7 1/4
52	391.25	14 1/2	7 1/4
53	397.25	14 1/4	7 1/8
54	403.25	14	7
55	409.25	13 3/4	6 7/8
56	415.25	13 1/2	6 3/4
57	421.25	13 1/4	6 5/8
58	427.25	13 1/4	6 5/8
59	433.25	13	6 1/2
60	439.25	12 3/4	6 3/8
61	445.25	12 1/2	6 1/4
62	451.25	12 1/2	6 1/4
63	457.25	12 1/4	6 1/8
64	463.25	12 1/4	6 1/8
65	469.25	12	6
66	475.25	11 3/4	5 7/8
67	481.25	11 3/4	5 7/8
68	487.25	11 1/2	5 3/4
69	493.25	11 1/2	5 3/4
70	499.25	11 1/4	5 5/8
71	505.25	11 1/4	5 5/8
72	511.25	11	5 1/2
73	517.25	11	5 1/2
74	523.25	10 3/4	5 3/8
75	529.25	10 3/4	53/8
76	535.25	10 1/2	5 1/4
77	541.25	10 1/2	5 1/4
78	547.25	10 1/4	5 1/8

**Element Length is the length of each element from the center of the dipole.

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
70.25	45 5/16	115.1
70.50	45 1/16	114.4
70.75	44 3/4	113.7
71.00	44 1/2	112.9
71.25	44	111.8
71.50	43 9/16	110.7
71.75	43 1/8	109.5
72.00	42 11/16	108.4
72.25	42 5/16	107.5
72.50	42	106.7
72.75	41 11/16	105.8
73.00	41 5/16	104.9
73.25	41 1/8	104.4
73.50	40 7/8	103.8
73.75	40 5/8	103.2
74.00	40 7/16	102.7
74.25	40 5/16	102.4
74.50	40 3/16	102.1
74.75	40 1/16	101.8
75.00	40	101.5
75.25	39 7/8	101.3
75.50	39 3/4	101.0
75.75	39 11/16	100.8
76.00	39 9/16	100.5
76.25	39 7/16	100.1
76.50	39 1/4	99.7
76.75	39 1/16	99.3
77.00	38 15/16	98.9
77.25	38 13/16	98.6
77.50	38 11/16	98.3
77.75	38 9/16	98.0
78.00	38 7/16	97.7
78.25	38 3/8	97.5
78.50	38 5/16	97.3
78.75	38 3/16	97.1
79.00	38 1/8	96.8
79.25	38 1/16	96.8
79.50	38 1/16	96.6
79.75	38	96.5
80.00	38	96.4
80.25	37 7/8	96.3
80.50	37 13/16	96.1
81.00	37 11/16	95.7
81.25	37 9/16	95.4
81.50	37 7/16	95.1
81.75	37 5/16	94.8
82.00	37 3/16	94.5
82.25	37 1/8	94.2
82.50	37	94.0
82.75	36 15/16	93.8

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
83.00	36 13/16	93.6
83.25	36 3/4	93.4
83.50	36 11/16	93.2
83.75	36 5/8	93.1
84.00	36 9/16	92.9
84.25	36 9/16	92.9
84.50	36 1/2	92.8
84.75	36 1/2	92.7
85.00	36 1/2	92.6
85.25	36 3/8	92.3
85.50	36 1/4	92.0
85.75	36 1/8	91.7
86.00	36	91.4
86.25	35 3/4	90.9
86.50	35 9/16	90.4
86.75	35 3/8	89.8
87.00	35 3/16	89.3
87.25	35	89.0
87.50	34 7/8	88.6
87.75	34 3/4	88.2
88.00	34 9/16	87.8
88.25	34 1/2	87.6
88.50	34 3/8	87.3
88.75	34 1/4	87.1
89.00	34 3/16	86.8
89.25	34 1/8	86.7
89.50	34 1/16	86.5
89.75	34	86.4
90.00	34	86.3
90.25	33 13/16	85.9
90.50	33 11/16	85.5
90.75	33 1/2	85.1
91.00	33 3/8	84.8
91.25	33 1/8	84.2
91.50	32 7/8	83.6
91.75	32 5/8	82.9
92.00	32 7/16	82.3
92.25	32 1/4	81.9
92.50	32 1/16	81.4
92.75	31 7/8	81.0
93.00	31 11/16	80.5
93.25	31 9/16	80.2
93.50	31 7/16	79.9
93.75	31 5/16	79.6
94.00	31 3/16	79.3
94.25	31 1/8	79.1
94.50	31 1/16	79.0
94.75	31	78.8
95.00	31	78.7

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
95.25	30 7/8	78.5
95.50	30 13/16	78.3
95.75	30 3/4	78.1
96.00	30 11/16	77.9
96.25	30 9/16	77.6
96.50	30 7/16	77.3
96.75	30 5/16	77.0
97.00	30 3/16	76.7
97.25	30 1/8	76.5
97.50	30	76.2
97.75	29 15/16	76.0
98.00	29 13/16	75.8
98.25	29 3/4	75.6
98.50	29 11/16	75.5
98.75	29 5/8	75.3
99.00	29 9/16	75.2
99.25	29 9/16	75.1
99.50	29 1/2	75.0
99.75	29 1/2	74.9
100.00	29 1/2	74.9
100.25	29 3/8	74.7
100.50	29 5/16	74.5
100.75	29 1/4	74.3
101.00	29 3/16	74.1
101.25	29 1/16	73.8
101.50	28 15/16	73.5
101.75	28 13/16	73.2
102.00	28 11/16	72.9
102.25	28 5/8	72.7
102.50	28 1/2	72.4
102.75	28 7/16	72.2
103.00	28 5/16	72.0
103.25	28 1/4	71.8
103.50	28 3/16	71.7
103.75	28 1/8	71.5
104.00	28 1/16	71.4
104.25	28 1/16	71.3
104.50	28	71.2
104.75	28	71.1
105.00	28	71.1
105.25	27 15/16	70.9
105.50	27 7/8	70.8
105.75	27 13/16	70.6
106.00	27 3/4	70.4
106.25	27 5/8	70.2
106.50	27 1/2	69.9
106.75	27 7/16	69.7
107.00	27 5/16	69.4
107.25	27 1/4	69.2

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
107.50	27 3/16	69.0
107.75	27 1/8	68.8
108.00	27	68.7
108.25	27	68.5
108.50	26 15/16	68.4
108.75	26 7/8	68.3
109.00	26 13/16	68.2
109.25	26 13/16	68.1
109.50	26 3/4	68.0
109.75	26 3/4	68.0
110.00	26 3/4	67.9
110.25	26 11/16	67.7
110.50	26 5/8	67.6
110.75	26 9/16	67.4
111.00	26 1/2	67.3
111.25	26 3/8	67.0
111.50	26 1/4	66.8
111.75	26 3/16	66.5
112.00	26 1/16	66.2
112.25	26	66.1
112.50	25 15/16	65.9
112.75	25 7/8	65.7
113.00	25 3/4	65.5
113.25	25 3/4	65.4
113.50	25 11/16	65.2
113.75	25 5/8	65.1
114.00	25 9/16	65.0
114.25	25 9/16	64.9
114.50	25 1/2	64.8
114.75	25 1/2	64.8
115.00	25 1/2	64.7
115.25	25 7/16	64.6
115.50	25 3/8	64.5
115.75	25 5/16	64.3
116.00	25 1/4	64.2
116.25	25 3/16	64.0
116.50	25 1/8	63.8
116.75	25	63.6
117.00	24 15/16	63.4
117.25	24 7/8	63.2
117.50	24 13/16	63.1
117.75	24 3/4	62.9
118.00	24 11/16	62.8
118.25	24 11/16	62.7
118.50	24 5/8	62.6
118.75	24 9/16	62.5
119.00	24 9/16	62.4
119.25	24 1/2	62.3
119.50	24 1/2	62.3

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
119.75	24 1/2	62.2
120.00	24 1/2	62.2
120.25	24 3/8	62.0
120.50	24 5/16	61.8
120.75	24 1/4	61.6
121.00	24 3/16	61.4
121.25	24 1/16	61.1
121.50	23 15/16	60.8
121.75	23 13/16	60.5
122.00	23 11/16	60.2
122.25	23 5/8	60.0
122.50	23 1/2	59.7
122.75	23 7/16	59.5
123.00	23 5/16	59.3
123.25	23 1/4	59.1
123.50	23 3/16	59.0
123.75	23 1/8	58.8
124.00	23 1/16	58.7
124.25	23 1/16	58.6
124.50	23	58.5
124.75	23	58.5
125.00	23	58.4
125.25	22 15/16	58.3
125.50	22 7/8	58.2
125.75	22 7/8	58.1
126.00	22 13/16	58.0
126.25	22 3/4	57.8
126.50	22 11/16	57.7
126.75	22 5/8	57.5
127.00	22 9/16	57.4
127.25	22 9/16	57.3
127.50	22 1/2	57.2
127.75	22 7/16	57.0
128.00	22 3/8	56.9
128.25	22 3/8	56.9
128.50	22 5/16	56.8
128.75	22 5/16	56.7
129.00	22 1/4	56.6
129.25	22 1/4	56.6
129.50	22 1/4	56.5
129.75	22 1/4	56.5
130.00	22 1/4	56.5
130.25	22 3/16	56.3
130.50	22 1/8	56.2
130.75	22 1/16	56.1
131.00	22	56.0
131.25	21 15/16	55.8
131.50	21 7/8	55.6
131.75	21 3/4	55.4
132.00	21 11/16	55.2

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
132.25	21 5/8	55.0
132.50	21 9/16	54.8
132.75	21 1/2	54.7
133.00	21 7/16	54.5
133.25	21 7/16	54.4
133.50	21 3/8	54.3
133.75	21 5/16	54.2
134.00	21 5/16	54.1
134.25	21 1/4	54.1
134.50	21 1/4	54.0
134.75	21 1/4	54.0
135.00	21 1/4	53.9
135.25	21 3/16	53.8
135.50	21 1/8	53.7
135.75	21 1/8	53.6
136.00	21 1/16	53.5
136.25	21	53.4
136.50	20 15/16	53.2
136.75	20 7/8	53.1
137.00	20 13/16	52.9
137.25	20 13/16	52.8
137.50	20 3/4	52.7
137.75	20 11/16	52.6
138.00	20 5/8	52.5
138.25	20 5/8	52.4
138.50	20 9/16	52.3
138.75	20 9/16	52.3
139.00	20 1/2	52.2
139.25	20 1/2	52.1
139.50	20 1/2	52.1
139.75	20 1/2	52.1
140.00	20 1/2	52.0
140.25	20 7/16	51.9
140.50	20 3/8	51.8
140.75	20 3/8	51.7
141.00	20 5/16	51.7
141.25	20 1/4	51.5
141.50	20 3/16	51.3
141.75	20 1/8	51.2
142.00	20 1/16	51.0
142.25	20 1/16	50.9
142.50	20	50.8
142.75	19 15/16	50.7
143.00	19 7/8	50.6
143.25	19 7/8	50.5
143.50	19 13/16	50.4
143.75	19 13/16	50.4
144.00	19 3/4	50.3
144.25	19 3/4	50.2

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
144.50	19 3/4	50.2
144.75	19 3/4	50.2
145.00	19 3/4	50.1
145.25	19 11/16	50.1
145.50	19 11/16	50.0
145.75	19 5/8	49.9
146.00	19 5/8	49.9
146.25	19 9/16	49.8
146.50	19 9/16	49.7
146.75	19 1/2	49.6
147.00	19 7/16	49.5
147.25	19 7/16	49.4
147.50	19 3/8	49.3
147.75	19 3/8	49.2
148.00	19 5/16	49.2
148.25	19 5/16	49.1
148.50	19 5/16	49.1
148.75	19 1/4	49.0
149.00	19 1/4	49.0
149.25	19 1/4	48.9
149.50	19 1/4	48.9
149.75	19 1/4	48.9
150.00	19 1/4	48.9
150.25	19 3/16	48.8
150.50	19 1/8	48.7
150.75	19 1/8	48.6
151.00	19 1/16	48.5
151.25	19	48.3
151.50	18 15/16	48.2
151.75	18 7/8	48.0
152.00	18 13/16	47.9
152.25	18 13/16	47.8
152.50	18 3/4	47.6
152.75	18 11/16	47.5
153.00	18 5/8	47.4
153.25	18 5/8	47.3
153.50	18 9/16	47.3
153.75	18 9/16	47.2
154.00	18 1/2	47.1
156.75	18 1/4	46.4
157.00	18 3/16	46.3
157.25	18 3/16	46.2
157.50	18 1/8	46.1
157.75	18 1/8	46.1
158.00	18 1/16	46.0
158.25	18 1/16	45.9
158.50	18 1/16	45.9
158.75	18	45.8

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
159.00	18	45.8
159.25	18	45.8
159.50	18	45.7
159.75	18	45.7
160.00	18	45.7
160.25	17 15/16	45.6
160.50	17 15/16	45.6
160.75	17 7/8	45.5
161.00	17 7/8	45.4
161.25	17 13/16	45.3
161.50	17 13/16	45.2
161.75	17 3/4	45.1
162.00	17 11/16	45.0
162.25	17 11/16	45.0
162.50	17 5/8	44.9
162.75	17 5/8	44.8
163.00	17 9/16	44.7
163.25	17 9/16	44.7
163.50	17 9/16	44.6
163.75	17 1/2	44.6
164.00	17 1/2	44.5
164.25	17 1/2	44.5
164.50	17 1/2	44.5
164.75	17 1/2	44.4
154.25	18 1/2	47.1
154.50	18 1/2	47.0
154.75	18 1/2	47.0
155.00	18 1/2	47.0
155.25	18 7/16	46.9
155.50	18 7/16	46.8
155.75	18 3/8	46.8
156.00	18 3/8	46.7
156.25	18 5/16	46.6
156.50	18 5/16	46.5
165.00	17 1/2	44.4
165.25	17 7/16	44.4
165.50	17 7/16	44.3
165.75	17 3/8	44.2
166.00	17 3/8	44.2
166.25	17 5/16	44.1
166.50	17 5/16	44.0
166.75	17 1/4	43.9
167.00	17 3/16	43.8
167.25	17 3/16	43.7
167.50	17 1/8	43.6
167.75	17 1/8	43.5
168.00	17 1/16	43.5
168.25	17 1/16	43.4

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
168.50	17 1/16	43.3
168.75	17	43.3
169.00	17	43.3
169.25	17	43.2
169.50	17	43.2
169.75	17	43.2
170.00	17	43.2
170.25	16 15/16	43.1
170.50	16 15/16	43.0
170.75	16 7/8	43.0
171.00	16 7/8	42.9
171.25	16 13/16	42.8
171.50	16 13/16	42.7
171.75	16 3/4	42.6
172.00	16 11/16	42.5
172.25	16 11/16	42.4
172.50	16 5/8	42.3
172.75	16 5/8	42.3
173.00	16 9/16	42.2
173.25	16 9/16	42.1
173.50	16 9/16	42.1
173.75	16 1/2	42.0
174.00	16 1/2	42.0
174.25	16 1/2	42.0
174.50	16 1/2	41.9
174.75	16 1/2	41.9
175.00	16 1/2	41.9
175.25	16 7/16	41.8
175.50	16 7/16	41.8
175.75	16 3/8	41.7
176.00	16 3/8	41.6
176.25	16 5/16	41.5
176.50	16 5/16	41.4
176.75	16 1/4	41.3
177.00	16 3/16	41.2
177.25	16 3/16	41.1
177.50	16 1/8	41.1
177.75	16 1/8	41.0
178.00	16 1/16	40.9
178.25	16 1/16	40.9
178.50	16 1/16	40.8
178.75	16	40.8
179.00	16	40.7
179.25	16	40.7
179.50	16	40.7
179.75	16	40.6
180.00	16	40.6
180.25	15 15/16	40.6

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
180.50	15 15/16	40.5
180.75	15 15/16	40.5
181.00	15 7/8	40.4
181.25	15 7/8	40.3
181.50	15 13/16	40.3
181.75	15 13/16	40.2
182.00	15 3/4	40.1
182.25	15 3/4	40.0
182.50	15 11/16	39.9
182.75	15 11/16	39.8
183.00	15 5/8	39.8
183.25	15 5/8	39.7
183.50	15 9/16	39.6
183.75	15 9/16	39.6
184.00	15 9/16	39.5
184.25	15 1/2	39.5
184.50	15 1/2	39.4
184.75	15 7/16	39.3
185.00	15 7/16	39.3
185.25	15 7/16	39.2
185.50	15 7/16	39.2
185.75	15 3/8	39.1
186.00	15 3/8	39.1
186.25	15 3/8	39.0
186.50	15 5/16	39.0
186.75	15 5/16	39.0
187.00	15 5/16	38.9
187.25	15 5/16	38.9
187.50	15 5/16	38.9
187.75	15 1/4	38.8
188.00	15 1/4	38.8
188.25	15 1/4	38.8
188.50	15 1/4	38.8
188.75	15 1/4	38.8
189.00	15 1/4	38.7
189.25	15 1/4	38.7
189.50	15 1/4	38.7
189.75	15 1/4	38.7
190.00	15 1/4	38.7
190.25	15 3/16	38.7
190.50	15 3/16	38.6
190.75	15 3/16	38.6
191.00	15 1/8	38.5
191.25	15 1/8	38.4
191.50	15 1/16	38.3
191.75	15 1/16	38.3
192.00	15	38.2
192.25	15	38.1

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
192.50	14 15/16	38.0
192.75	14 15/16	37.9
193.00	14 7/8	37.9
193.25	14 7/8	37.8
193.50	14 13/16	37.7
193.75	14 13/16	37.7
194.00	14 13/16	37.6
194.25	14 3/4	37.5
194.50	14 3/4	37.5
194.75	14 11/16	37.4
195.00	14 11/16	37.4
195.25	14 11/16	37.3
195.50	14 11/16	37.3
195.75	14 5/8	37.2
196.00	14 5/8	37.2
196.25	14 5/8	37.1
196.50	14 9/16	37.1
196.75	14 9/16	37.1
197.00	14 9/16	37.0
197.25	14 9/16	37.0
197.50	14 9/16	37.0
197.75	14 1/2	36.9
198.00	14 1/2	36.9
198.25	14 1/2	36.9
198.50	14 1/2	36.9
198.75	14 1/2	36.9
199.00	14 1/2	36.8
199.25	14 1/2	36.8
199.50	14 1/2	36.8
199.75	14 1/2	36.8
200.00	14 1/2	36.8
200.25	14 7/16	36.7
200.50	14 7/16	36.7
200.75	14 3/8	36.6
201.00	14 3/8	36.5
201.25	14 5/16	36.4
201.50	14 1/4	36.3
201.75	14 1/4	36.2
202.00	14 3/16	36.1
202.25	14 1/8	36.0
202.50	14 1/8	35.9
202.75	14 1/16	35.8
203.00	14	35.7
203.25	14	35.6
203.50	13 15/16	35.5
203.75	13 15/16	35.4
204.00	13 7/8	35.3
204.25	13 7/8	35.3

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
204.50	13 13/16	35.2
204.75	13 13/16	35.1
205.00	13 3/4	35.0
205.25	13 3/4	35.0
205.50	13 3/4	34.9
205.75	13 11/16	34.8
206.00	13 11/16	34.8
206.25	13 5/8	34.7
206.50	13 5/8	34.7
206.75	13 5/8	34.6
207.00	13 9/16	34.6
207.25	13 9/16	34.5
207.50	13 9/16	34.5
207.75	13 9/16	34.5
208.00	13 1/2	34.4
208.25	13 1/2	34.4
208.50	13 1/2	34.4
208.75	13 1/2	34.3
209.00	13 1/2	34.3
209.25	13 1/2	34.3
209.50	13 1/2	34.3
209.75	13 1/2	34.3
210.00	13 1/2	34.3
210.25	13 7/16	34.2
210.50	13 7/16	34.2
210.75	13 7/16	34.2
211.00	13 7/16	34.1
211.25	13 3/8	34.1
211.50	13 3/8	34.0
211.75	13 3/8	34.0
212.00	13 5/16	33.9
212.25	13 5/16	33.9
212.50	13 5/16	33.8
212.75	13 1/4	33.8
213.00	13 1/4	33.7
213.25	13 1/4	33.7
213.50	13 3/16	33.6
213.75	13 3/16	33.6
214.00	13 3/16	33.5
214.25	13 3/16	33.5
214.50	13 1/8	33.5
214.75	13 1/8	33.4
215.00	13 1/8	33.4
215.25	13 1/8	33.3
215.50	13 1/8	33.3
215.75	13 1/16	33.3
216.00	13 1/16	33.3
216.25	13 1/16	33.2
216.50	13 1/16	33.2

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
216.75	13 1/16	33.2
217.00	13	33.2
217.25	13	33.1
217.50	13	33.1
217.75	13	33.1
218.00	13	33.1
218.25	13	33.1
218.50	13	33.0
218.75	13	33.0
219.00	13	33.0
219.25	13	33.0
219.50	13	33.0
219.75	13	33.0
220.00	13	33.0
220.25	12 15/16	33.0
220.50	12 15/16	32.9
220.75	12 15/16	32.9
221.00	12 15/16	32.9
221.25	12 7/8	32.8
221.50	12 7/8	32.8
221.75	12 7/8	32.7
222.00	12 13/16	32.6
222.25	12 13/16	32.6
222.50	12 13/16	32.5
222.75	12 3/4	32.5
223.00	12 3/4	32.4
223.25	12 3/4	32.4
223.50	12 11/16	32.3
223.75	12 11/16	32.3
224.00	12 11/16	32.3
224.25	12 11/16	32.2
224.50	12 5/8	32.2
225.00	12 5/8	32.1
225.25	12 5/8	32.1
225.50	12 5/8	32.0
225.75	12 9/16	32.0
226.00	12 9/16	32.0
226.25	12 9/16	32.0
226.50	12 9/16	31.9
226.75	12 9/16	31.9
227.00	12 1/2	31.9
227.25	12 1/2	31.9
227.50	12 1/2	31.8
227.75	12 1/2	31.8
228.00	12 1/2	31.8
228.25	12 1/2	31.8
228.50	12 1/2	31.8
228.75	12 1/2	31.8
229.00	12 1/2	31.8

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
229.25	12 1/2	31.7
229.50	12 1/2	31.7
229.75	12 1/2	31.7
230.00	12 1/2	31.7
230.25	12 7/16	31.7
230.50	12 7/16	31.7
230.75	12 7/16	31.6
231.00	12 7/16	31.6
231.25	12 3/8	31.5
231.50	12 3/8	31.5
231.75	12 3/8	31.4
232.00	12 5/16	31.4
232.25	12 5/16	31.3
232.50	12 5/16	31.3
232.75	12 1/4	31.2
233.00	12 1/4	31.2
233.25	12 1/4	31.1
233.50	12 3/16	31.1
233.75	12 3/16	31.0
234.00	12 3/16	31.0
234.25	12 3/16	31.0
234.50	12 1/8	30.9
234.75	12 1/8	30.9
235.00	12 1/8	30.8
235.25	12 1/8	30.8
235.50	12 1/8	30.8
235.75	12 1/16	30.7
236.00	12 1/16	30.7
236.25	12 1/16	30.7
236.50	12 1/16	30.7
236.75	12 1/16	30.6
237.00	12	30.6
237.25	12	30.6
237.50	12	30.6
237.75	12	30.6
238.00	12	30.5
238.25	12	30.5
238.50	12	30.5
238.75	12	30.5
239.00	12	30.5
239.25	12	30.5
239.50	12	30.5
239.75	12	30.5
240.00	12	30.5
240.25	11 15/16	30.4
240.50	11 15/16	30.4
240.75	11 15/16	30.4
241.00	11 15/16	30.3

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
241.25	11 7/8	30.3
241.50	11 7/8	30.2
241.75	11 7/8	30.2
242.00	11 13/16	30.1
242.25	11 13/16	30.0
242.50	11 13/16	30.0
242.75	11 3/4	30.0
243.00	11 3/4	29.9
243.25	11 3/4	29.9
243.50	11 11/16	29.8
243.75	11 11/16	29.8
244.00	11 11/16	29.7
244.50	11 5/8	29.6
244.75	11 5/8	29.6
245.00	11 5/8	29.6
245.25	11 5/8	29.5
245.50	11 5/8	29.5
245.75	11 9/16	29.5
246.00	11 9/16	29.4
246.25	11 9/16	29.4
247.00	11 1/2	29.3
247.75	11 1/2	29.3
248.00	11 1/2	29.3
248.25	11 1/2	29.2
248.50	11 1/2	29.2
248.75	11 1/2	29.2
249.00	11 1/2	29.2
249.25	11 1/2	29.2
249.50	11 1/2	29.2
249.75	11 1/2	29.2
250.00	11 1/2	29.2
250.25	11 7/16	29.2
250.50	11 7/16	29.1
250.75	11 7/16	29.1
251.00	11 7/16	29.1
251.25	11 3/8	29.0
251.50	11 3/8	28.9
251.75	11 3/8	28.9
252.00	11 5/16	28.8
252.25	11 5/16	28.8
252.50	11 5/16	28.7
252.75	11 1/4	28.7
253.00	11 1/4	28.6
253.25	11 1/4	28.6
253.50	11 3/16	28.5
253.75	11 3/16	28.5
254.00	11 3/16	28.5
254.25	11 3/16	28.4
254.50	11 1/8	28.4

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
254.75	11 1/8	28.3
255.00	11 1/8	28.3
255.25	11 1/8	28.3
255.50	11 1/8	28.2
255.75	11 1/16	28.2
256.00	11 1/16	28.2
256.25	11 1/16	28.1
256.50	11 1/16	28.1
256.75	11 1/16	28.1
257.00	11	28.1
257.25	11	28.0
257.50	11	28.0
257.75	11	28.0
258.00	11	28.0
258.25	11	28.0
258.50	11	28.0
258.75	11	28.0
259.00	11	27.9
259.25	11	27.9
259.50	11	27.9
259.75	11	27.9
260.00	11	27.9
260.25	10 5/16	27.9
260.50	10 5/16	27.9
260.75	10 5/16	27.8
280.75	10	25.4
281.00	10	25.4
281.25	10	25.4
281.50	10	25.4
281.75	10	25.4
282.00	10	25.4
282.25	10	25.4
282.50	10	25.4
282.75	10	25.4
283.00	10	25.4
283.25	10	25.4
283.50	10	25.4
283.75	10	25.4
284.00	10	25.4
284.25	10	25.4
284.50	10	25.4
284.75	10	25.4
285.00	10	25.4
285.25	10	25.4
285.50	10	25.4
285.75	10	25.4
286.00	10	25.4
286.25	10	25.4
286.50	10	25.4

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
286.75	10	25.4
287.00	10	25.4
287.25	10	25.4
287.50	10	25.4
287.75	10	25.4
288.00	10	25.4
288.25	10	25.4
288.50	10	25.4
288.75	10	25.4
289.00	10	25.4
271.50	10 3/8	26.4
271.75	10 3/8	26.3
272.00	10 5/16	26.3
272.25	10 5/16	26.2
272.50	10 5/16	26.2
272.75	10 1/4	26.1
273.00	10 1/4	26.1
273.25	10 1/4	26.0
273.50	10 3/16	26.0
273.75	10 3/16	26.0
274.00	10 3/16	25.9
274.25	10 3/16	25.9
274.50	10 1/8	25.8
274.75	10 1/8	25.8
275.00	10 1/8	25.8
275.25	10 1/8	25.7
275.50	10 1/8	25.7
275.75	10 1/16	25.7
276.00	10 1/16	25.6
276.25	10 1/16	25.6
276.50	10 1/16	25.6
276.75	10 1/16	25.6
276.00	10	25.5
276.25	10	25.5
276.50	10	25.5
276.75	10	25.5
277.00	10	25.5
277.25	10	25.4
277.50	10	25.4
277.75	10	25.4
278.00	10	25.4
278.25	10	25.4
278.50	10	25.4
278.75	10	25.4
279.00	10	25.4
279.25	10	25.4
279.50	10	25.4
279.75	10	25.4
280.00	10	25.4

CHART 2 ANTENNA ELEMENT LENGTHS FOR LD-2 DIPOLE

Frequency in Megahertz	Element Length in Inches	Element Length in Centimetres
280.25	10	25.4
280.50	10	25.4
280.75	10	25.4
281.00	10	25.4
281.25	10	25.4
281.50	10	25.4
281.75	10	25.4
282.00	10	25.4
282.25	10	25.4
282.50	10	25.4
282.75	10	25.4
283.00	10	25.4
283.25	10	25.4
283.50	10	25.4
283.75	10	25.4
284.00	10	25.4
284.25	10	25.4
284.50	10	25.4
284.75	10	25.4
285.00	10	25.4
285.25	10	25.4
285.50	10	25.4
285.75	10	25.4
286.00	10	25.4
286.25	10	25.4
286.50	10	25.4
286.75	10	25.4
287.00	10	25.4
287.25	10	25.4
287.50	10	25.4
287.75	10	25.4
288.00	10	25.4
288.25	10	25.4
288.50	10	25.4
288.75	10	25.4
289.00	10	25.4

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